CSIR NEWS

VOL. 20 30 DECEMBER 1970 : 9 PAUSHA 1892 NO. 24

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Radio-tracer Laboratory Set Up at CECRI

In view of the vast scope for the application of radio-tracer technique in the field of electrochemistry, a radio-tracer laboratory has been set up at the Central Electrochemical Research Institute (CECRI), Karaikudi. The laboratory was formally inaugurated by Dr Atma Ram, Director General, Scientific & Industrial Research, on 24 November 1970.

The laboratory (area, 2500 sq ft) is of conventional design and consists of a high activity room with separate storage space, a low activity room, a counting room, a showerbath room, a monitoring room and a personnel room. The plan of the laboratory was approved by the Health Physics Division of the Bhabha Atomic Research Centre, Bombay. The walls of the laboratory have been coated on the inside with titanium dioxide rubber-based paint and later with strippable lacquer to facilitate decontamination. Special arrangements have been made for the disposal of the laboratory waste directly into a pit in a remote corner of the campus. Facilities have been created for working with beta- and gamma-ray emitting substances.

An idea of the scope of work of the laboratory can be had from the following types of studies which could be envisaged : (i) effect of adsorption of various substances on electrode processes such as the hydrogen evolution reaction, anodic polarization, oxygen evolution reaction, changes in the double layer structure at the metal-solution interface and exchange between metal and metal ions in solution ; (ii) mechanism of inhibition of corrosion of metals by various corrosion inhibitors, phenomenon of anodic passivation and depassivation, role of minor alloying constituents on the corrosion behaviour of alloys and the process of pitting corrosion of metals ; (iii) mechanism of action of brightening agents used in electroplating, the growth of electrodeposits, diffusion of electrodeposits into the metal substrate, influence of corrosive and passivating types of ions on the anodic oxidation of metals like aluminium, titanium and tantalum and mechanism of alloy plating ; (iv) course of organic and inorganic reactions brought about by electrochemical reduction or oxidation ; and (v) performance of battery additives, and effect of radiations on power sources.

At present some studies involving beta-emitters have been taken up. For example, the adsorption of radioactive calcium on aluminium immersed in sodium hydroxide solution has been investigated, following an earlier observation that a combination of calcium and citrate substantially inhibits the corrosion of aluminium in this solution. This investigation has proved that the inhibition observed is not due to the adsorption of calcium on the metal surface.

Another study under way is concerned with the adsorption of dibutyl sulphide containing radioactive sulphur on steel, copper, zinc and aluminium in sulphuric acid. The amount of the organic sulphide adsorbed is found to be different for different metals.

Dr Atma Ram, Director General, Scientific & Industrial Research, inaugurating the Radio-tracer Laboratory at CECRI, Karaikudi on 24 November 1970

In the future programmes of work in the radio-tracer laboratory, studies of various corrosion inhibitors, passivation of metals, mechanism of depassivation by corrosive ions like halides and pitting corrosion of metals are envisaged. It is proposed to study the action of brightening agents in electroplating and also the growth of electrodeposits. Various fundamental studies also, as indicated earlier, will be taken up.

Boric Acid from Borax

Boric acid is obtained by the purification of native boric acid or by the interaction of sulphuric acid with native borates. Calcium borate is usually employed for the manufacture of boric acid since the reaction product, calcium sulphate, can be removed easily. Use of sodium borate as a raw material poses some technical problems since both sodium sulphate (byproduct) and boric acid are soluble in water and their separation is difficult. However, due to difficulties in the procurement of calcium borate through import, sodium borate is required to be used as the raw material. The possibility of processing crude borax (sodium borate) for the production of boric acid has been investigated by the Central Salt & Marine Chemicals Research Institute, Bhavnagar under a project sponsored by Borax Morarji, Ambernath. Batches of 200 kg of raw material were processed to obtain necessary technical data. It was found that the recovery of technical grade boric acid was 90% using borax as raw material. Pharmaceutical grade purity was achieved by washing with a special surface active agent. Sodium sulphate recovery was 80%. A complete technical report has been submitted to the firm.

Recovery of Marine Salts in Aqueous and Aqueous-Organic Systems from Sea Bittern

Sea bittern is a rich source for many chemicals, particularly chlorides and sulphates of sodium, potassium and magnesium. These chemicals are lost in the form of bittern which is thrown back to sea as a waste liquor after the salt is collected. As there are no reserves of potash and sulphur in the country, there is great need for recovering them from the bittern, particularly when salt production is of the order of 4.5 million tonnes/annum. Studies were therefore carried out by Shri J.R. Sanghavi of the Central Salt and Marine Chemicals Research Institute (CSMCRI), Bhavnagar with a view to evolving processes for their recovery from bittern and its evaporites. The recovery of the marine salts is based on mutual solubilities in aqueous-organic media as well as aqueous media. For rapid determination of sodium and potassium in samples of brine, bittern and its evaporites, flame photometric technique was adopted with suitable modifications to obviate the interference by cations and anions present in the samples. A systematic study was carried out on solar evaporation of bittern to obtain sels mixts and mixed salt, concentrated sources for magnesium sulphate and potassium chloride respectively. It was observed that potassium chloride recovery was 63.7% and that of magnesium sulphate was 60.3% when bittern was evaporated without artificially raising magnesium chloride concentration. Potassium chloride recovery increased to 67.3% when magnesium chloride in bittern was raised. Thus, a procedure was established for recovering the concentrated sources for potassium chloride and magnesium sulphate by solar evaporation of bittern.

Recovery of Sodium Sulphate from Bittern and Sels Mixts using Methanol

The reaction between sodium chloride and magnesium sulphate in various aqueous-organic solvents, such as ethanol, methanol, *n*-propanol and acetone, was studied. The results were applied to bittern and sels mixts. The study led to the development of a process for the recovery of technical grade sodium sulphate from bittern and sels mixts using 50% methanol mixture, with 96% yield. The new process does away with all the steps involved in the conventional method. It does not require chilling to below zero temperatures. The product obtained is sodium sulphate and hence does not require dehydration.

Recovery of Potassium Sulphate from Mixed Salt using Methanol

The reaction between potassium chloride and magnesium sulphate in the aqueous-organic solvents, mentioned above, was studied. The results showed that methanol is the most suitable solvent giving higher purity and yield of potassium sulphate. Potassium sulphate cannot be obtained directly from such a mixture in aqueous system. The results were applied first to kainite ($KCl.\ MgSO_4.3H_2O$) and then to mixed salt for recovering potassium sulphate. As a result, a process was established for the recovery of fertilizer grade potassium sulphate from mixed salt in 50% water-methanol mixture at room temperature.

Solubility of Salts in Methanol-Water Mixture

The solubilities of the salts in methanol-water mixtures were determined at 30°C. Sodium chloride and potassium chloride were less soluble in aqueous methanol; the solubilities were a little higher at 30°C than at 25°C. Magnesium sulphate lost its water of hydration in the solid phase as methanol concentration increased. Two new solid phases, $MgCl_2\ 4CH_3OH\ 2H_2O$ and $MgCl_2\ 2CH_3OH\ 4H_2O$, were identified in the case of magnesium chloride-methanol-water system at 30°C.

Potash Alum from Mixed Salt

Potash alum is prepared from potassium sulphate and aluminium sulphate. The study was undertaken to utilize mixed salt as a source for potassium sulphate in the preparation of potash alum. A process for recovering potassium from mixed salt as potassium sulphate in the form of potash alum (technical grade, 87% yield) was worked out. Apart from using mixed salt as a source of potassium sulphate, the process has the following advantages : (1) it is simple and recoveries of potassium and aluminium are very high; and (2) even though iron containing aluminium sulphate is used, the product is iron-free, which is a necessary prerequisite for its use in dyeing.

Recovery of Potassium Chloride from Bittern

The results of experiments on evaporation of desulphated brine and bittern showed that about 75% of potassium chloride is recovered as carnallite. On decomposing carnallite with water at room temperature 85% of potassium chloride was recovered. During the experimental study on the recrystallization of impure potassium chloride by sodium chloride-potassium chloride solution, it was observed that the efficiency of the solution decreased due to magnesium chloride concentration on recycling. A procedure was evolved for the recovery of potassium chloride from this solution.

Shri Sanghavi, who carried out the studies under the guidance of Dr K. Seshadri of the institute, was awarded the Ph.D. degree by the Gujarat University (1970) for the thesis entitled 'Studies on the recoveries of sodium sulphate and potassium sulphate in aqueous-organic systems and potash alum and potassium chloride in aqueous systems from sea bittern.'

PROGRESS REPORTS

RRL, Hyderabad Annual Report: 1968-69

Processing of sal seed for producing fat, development of a continuous process for the preparation of fatty alcohols from coconut oil in high yields, development of various grades of colloidal graphite in different media, improved process for 2,4-D, and cellulose based filter aids are among the important processes and products developed by the Regional Research Laboratory (RRL), Hyderabad during 1968-69. The annual report of the laboratory, published recently, records the progress of work under the following main heads: Oils and fats; Surface coatings; Organic chemistry, industrial intermediates, drugs and pesticides; Cellulose and paper; Entomology; Biochemistry; Heavy chemicals and fertilizers; Industrial ceramics; X-ray crystallography; Instrumentation; and Chemical engineering.

Investigations on the processing of sal (*Shorea robusta*) seed (available in commercial quantities from the forests of Orissa and Madhya Pradesh) for producing fat were successfully completed under a sponsored project. The solid hard fat can be used as a substitute and extender for cocoa butter, which is being imported. A feasibility report for the economic exploitation of the seed was also prepared for the sponsor. A continuous process for the conversion of coconut oil into fatty alcohols (presently imported) in high yields under comparatively low pressures than those conventionally employed has been developed on a laboratory scale. The process consists in passing the oil through a tubular fixed-bed metal reactor containing the copper-chromium catalyst in pelletized form in a cocurrent stream with hydrogen gas under 80 atm pressure at 250°-350°C. The advantage of the process is that it dispenses with the use of costly high pressure equipment. A feasibility report for setting up a commercial plant for processing cottonseed (100 tonnes/day) into edible flour using the Punjab variety of cottonseed was prepared for the Punjab State Industrial Development Corporation Ltd. A new process for making low gossypol high protein flour from cottonseed using fluid cyclones is being worked out.

Development of various grades of stable colloidal graphite in different media, such as water, white spirit, liquid paraffin and lubricating oil was a significant contribution in the field of surface coating, as lubricants based on colloidal graphite are presently imported. The paraffin based graphite has been tested by glass manufacturing firms and found suitable for use in moulding. Modified formulations of anticorrosive paints developed by RRL for use on ship bottoms are being evaluated by the Shipping Corporation of India, Visakhapatnam and the Naval Chemical and Metallurgical Laboratory, Bombay.

An improved process for the manufacture of 2,4-dichlorophenoxyacetic acid (2,4-D), an important weedicide, from dichlorophenol has been worked out on a laboratory scale.

A feasibility report on the production of domestic coke by low temperature carbonization of coal (120 tonnes/day) was prepared for the Government of Maharashtra. A similar plant offered in collaboration with RRL, Bhubaneswar to the Industrial Development Corporation of Orissa Ltd was accepted.

An important project in the field of industrial ceramics under investigation at the laboratory was the production of abrasive grade silicon carbide. Conditions for the raw material preparation, furnacing operation to produce about 75 kg of product per run, grain treatment and grit preparation were established. Nearly 1.5 tonnes of abrasive grade material and 1 tonne of refractory grade material were produced. The grain produced has found acceptance by industry; the product has been found satisfactory not only for use as an abrasive but also for the preparation of semiconductors and lightning arrestor discs. At the instance of Singareni Collieries Co. Ltd, the laboratory took up investigations on the processing of slack coal, large quantities of which accumulate at pit heads. A four-stage method of producing domestic or formed coke on a plant of 50 tonnes/hr capacity was suggested as a long-term solution. The stages involved are: (i) fluidized-bed or other suitable method of carbonization of slack coal; (ii) briquetting using the tar obtained in the first step; (iii) maturing of the briquettes; and (iv) carbonization of the briquettes if metallurgical fuel is desired. Pressure gasification of coal (6-20 mm) for town gas was also suggested.

The plant of Orgaroma India Private Ltd, Hyderabad for manufacturing benzyl chloride and related chemicals, for which the laboratory provided know-how on turn-key basis, went into production. Further work on the development of process know-how to manufacture benzyl group of chemicals will be carried out jointly with the firm at their plant. Trial production of Lounginin, a synthetic flavouring

agent developed by the laboratory, was started by the Standard Products Manufacturing Co., Hyderabad. Commercial production of two other products developed by the laboratory, viz. sodium azide and cardanol, was also started. Four processes/products developed by the laboratory were released to industry for commercial utilization. These included: (i) X-ray grade barium sulphate (Tibson Pharmaceuticals Pvt. India Ltd, Calcutta); (ii) slide rules (Harvin Fotokarve, Hyderabad); (iii) benzenesulphonic acid methyl ester (Synthetic Drugs Project of the Indian Drugs & Pharmaceuticals Ltd); and (iv) palmarosa oil (several parties).

Three patents were taken, one each with respect to (i) synthesis of hexaphenylcyclotrisiloxane; (ii) synthesis of isobutyl ethyl orthosilicate mixtures and their polymers; and (iii) production of pale coloured adhesive from cardanol. Seven patents were accepted. Over sixty research papers were published.

CSIR SUPPORT TO RESEARCH

New Schemes

Multiple-phase Flow of Fluids through Porous Media

A major problem in petroleum industry is the ability to predict the rate at which oil can be produced from a reservoir. This requires a knowledge of simultaneous flow of oil, water and gas at great depths through porous sands and the permeability of the deep-seated porous medium to these fluids. Relaxation times derived from nuclear magnetic resonance studies could be correlated with the properties of porous media such as grain size distribution, and of fluids and solids. If the basic properties of the porous media, and of the fluids and the nature of their interaction can be correlated with NMR results, it should be possible to develop a tool capable of predicting the deliverability of a porous medium under investigation underground. In a new CSIR research scheme, granted to Dr D. N. Saraf (principal investigator) of the Department of Chemical Engineering, Indian Institute of Technology, Kanpur, it is proposed to study the solid-liquid interaction in flow systems under dynamic conditions employing NMR techniques. It is also proposed to make multiple-phase flow studies through porous materials and to correlate the results with a view to arriving at a theory for the production of multiple-phase flow behaviour. The development of an NMR logging tool which will enable the measurement of *in situ* permeabilities of petroleum reservoirs is also envisaged.

Surface Boiling on Different Metallic Surfaces: Application in Design of Heat Exchangers

Jet aircraft engines, rocket engines and nuclear reactors develop enormous quantities of heat which cannot be removed by conventional methods of cooling. Surface boiling is an efficient method which can remove the excess heat and this principle can be made use of in designing heat exchangers. A systematic study of surface boiling on different metallic surfaces with respect to different coolants with a view to utilizing the data in the design of heat exchangers used in petroleum refining and nuclear power plants is the subject of a new CSIR scheme. Dr C. Chiranjivi of the Department of Chemical Engineering, Andhra University, Waltair is the principal investigator in the research scheme.

Promotion of Drop-wise Condensation of Steam

Drop-wise pattern of steam is unstable compared to the film-wise pattern. In recent years some investigators were successful in obtaining drop-wise pattern and retaining it for longer periods. However, metal surfaces possessing the requisite thermal, physical and chemical properties that do not require an additional reagent to induce this pattern are yet to be developed for fabricating process heaters and condensers within economical range. Drop-wise condensers will be of great advantage for use in marine condensers and desalination equipment. Under a new CSIR research scheme sanctioned at the Department of Chemical Engineering, Indian Institute of Technology, Madras, Dr T. Venkatram proposes to investigate into a permanent system promoting drop-wise condensation of steam. Using data acquired with wide ranges of variables, a procedure would be developed for designing drop-wise condensers. Development of a computer programme for evaluating the data is also envisaged.

Development of Block Copolymers

Block copolymers are comparatively recent developments in the field of polymers and are acquiring great commercial importance because of two main factors. First, the polymers can be tailor-made to give desired properties and secondly, they are cheap as they are based on cheap petrochemical raw materials. Detailed information on the catalyst systems used for the preparation of these polymers is not available, although a few patents suggest the use of alkali metal alkyls as the ionic catalysts for the preparation of block copolymers. Under a new CSIR research scheme sanctioned at the Shri Ram Institute for Industrial Research, Delhi, Dr R. T. Thampy (principal investigator) proposes to develop the technology for the manufacture of styrene/butadiene block copolymers of commercial importance.

Dynamic Behaviour of Scooter

Although single-track vehicles, particularly scooters, are becoming increasingly popular in the country and attempts are being made by several manufacturers to bring indigenous models into market, the state of art of designing such vehicles is largely based on past experience and empirical approach. Comparatively little theoretical effort has gone into analysing the motion and optimizing the design. The performance and ride characteristics of a single-track vehicle depend on its various geometrical, mass and inertia parameters and on the characteristics of tyres used on the machine. The factors that affect the stability of two-wheeled vehicles at high speed also affect their handling characteristics at lower speeds.

Dr D. V. Singh of the Department of Mechanical Engineering, University of Roorkee, Roorkee has investigated the stability problem of two-wheeled vehicles and developed stability criteria. He has also studied the prototype of Rajdoot scooter (of Escorts Ltd) for its dynamic characteristics. Under a new CSIR research scheme sanctioned to him, Dr Singh proposes to study a commercial scooter for its dynamic characteristics on a more extensive basis taking into account tyre-road interaction and wind forces. The mathematical model of pneumatic tyres developed by him will be checked with the experimental data from tests on actual tyres. The results of the investigation would be of considerable interest to indigenous scooter manufacturers.

Pressure Drop in Two-Phase Two-Component Flow

A perusal of literature shows that there is no general formula for predicting pressure drop in two-phase flow. This is due to the large number of variables involved. Prof. B. N. Chanda of the Department of Mehanical Engineering, Jadavpur University, Calcutta has recently developed an expression to predict pressure drop in horizontal annual isothermal two-phase two-component flow when void fraction is known. Under a CSIR scheme granted to him Prof. Chandra proposes to develop a rational expression for pressure drop starting from the fundamental equations of fluid flow and thermodynamics with simplified assumptions. Experimental work will include determination of pressure drop in circular pipes as well as flow pattern. The results of the study are expected to be of use in the design of nuclear reactors.

Dissolution Studies on Zinc Ferrite Recovery

Substantial amount of zinc is lost as zinc ferrite when Zn-Fe-S ore is roasted for conversion to oxide prior to leaching and hydrometallurgical recovery of zinc. Zinc ferrite is not soluble in mineral acids at ordinary temperature. It has been reported that as much as 3-4 tonnes of zinc are lost at the Hindustan Zinc Plant, Udaipur through the formation of difficultly soluble zinc ferrite. Under a new CSIR research scheme sanctioned at the Department of Metallurgical Engineering, Indian Institute of Technology, Kanpur, Dr A. K. Biswas (principal investigator) proposes to investigate the kinetics of dissolution of synthetic zinc ferrite in acid solutions at different temperatures. After the completion of the fundamental studies, investigations on the leaching of the residue obtained at the Hindustan Zinc Plant will be carried out on a laboratory scale. The results of the study are expected to lead to the design of a zinc ferrite dissolution plant.

Mechanism of Reduction of Chromite Single Pellets

The object of a new CSIR research scheme granted to Dr A. Ghosh (principal investigator) at the Department of Metallurgical Engineering, Indian Institute of Technology, Kanpur is to elucidate the mechanism of reduction of chromite with a view to working out beneficiation methods for low grade chromite ores found abundantly in the country. The principal investigator proposes to study the mechanism by experimentation on dense, synthetically prepared chromites of controlled geometry. Single pellets will be employed and the mechanism will be evaluated from the microscopy of partially reduced pellets and from the data obtained on the rate of reduction.

Multiple Input System Models for a Basin for Estimation and Forecasting of Floods

Several conceptual models, viz. linear, quasi-linear and non-linear system models and time variant system models, have been proposed for the hydrologic basin system that transforms the effective rainfall into the direct surface run-off. However, these are generally lumped parameter system models or distributed parameter system models. Such procedures do not make full use of the available information since the input data are usually station precipitation values which are not directly used in the analysis. Under a new CSIR research scheme granted to Dr S. Ramaseshan (principal investigator) at the Department of Civil Engineering, Indian Institute of Technology, Kanpur, it is proposed to consider the basin system as a multiple input system, each input corresponding to the precipitation in a raingauge station. Using conventional procedures and conceptual system models the parameter of the system will be evaluated. The station weights and the system parameters will be evaluated using the steepest gradient method and the method of least squares. The linearity of the system will be tested and, if necessary, quasi and/or nonlinear models will be formulated. The results will be compared with those of lumped parameter models. Both digital and analogue computers will be used independently to solve the problem and in system synthesis. The results are expected to lead to a better and more direct estimation and forecasting of floods.

Finite Element Analysis of Couple Stresses and Diffusion and Stochastic Processes

The finite element method has a great potential use in the analysis of multi-dimensional problems of soils and rock mechanics under static and dynamic loads. The object of a new CSIR research scheme granted to Dr Bhavani Singh (principal investigator) at the Regional Engineering College, Kurukshetra, is to formulate finite element procedure for basic problems of mechanics and analyse known field behaviour of earth dam and other structures so that proper design recommendation could be made for their safety and reliability. Fundamental matrices will be developed for basic problems of mechanics, e.g. stress distribution, couple stresses, seepage, consolidation and stochastic processes for both two- and three-dimensional elements. A general computer programme will be prepared which will consider (i) stress relaxation due to consolidation, (ii) static and dynamic loads, and (iii) sequence of construction. In view of the large number of elements and consequential increase in the input data, a general programme to generate input data for all geometries of the

body will be prepared. Computations will be compared with closed form solutions. Field performance of the actual structures will be analysed. The next phase of work will be concerned with random variation in the material characteristics and random (seismic) vibrations. Field data will be analysed to find out the actual density fluctuations for various material characteristics, e.g. soil density, modulus of deformation, compressibility, permeability and coefficient of consolidation. Computations will be made to find out the density function for displacements and stresses, and the probability of failure will be worked out. The final phase of work will relate to evolving designs for structures from the points of view of safety and reliability.

Completed Schemes

Beneficiation of Sulphide Minerals by Froth Flotation Technique

The froth flotation technique for the separation of economic minerals from the gangue minerals is probably one of the most impressive technical applications of surface chemistry. More than 10^9 tons of ore are concentrated per annum by the froth flotation method. The efficacy of the method lies in the selective separation of one economic constituent from another when two or more similar minerals occur together in the same ore body.

As bulk of the mineral beneficiation by froth flotation is brought about by soluble collectors, the introduction of alkyl xanthates as collectors for sulphide minerals in 1923 made possible a systematic probe into the possible mechanism of collection. After forty years of extensive investigations, researchers are of the opinion that the flotation surface of a sulphide mineral is a mixed layer of heavy metal xanthate and its oxidation product, dixanthogen.

Shri K. Ravindranath, a CSIR research fellow, working under the supervision of Prof. C. C. Patel at the Department of Inorganic and Physical Chemistry, Indian Institute of Science, Bangalore has made a study of another type of thiocarbonyl compounds, viz. dialkyldithiocarbamates, with reference to the 'collecting capacity' of sulphide minerals, since these compounds received very little attention.

As a first step, the stabilities of soluble diethyl, diisopropyl, di-*n*-butyl and diisobutyldithiocarbamates in the presence of oxygen and carbon dioxide (active constituents of atmosphere where flotation is carried out) was investigated, as a function of *p*H and time and in the presence and absence of copper (II), iron (III), lead (II) and zinc (II). It was found that the higher dithiocarbamates are stable in the presence of oxygen, while the lower members undergo very slight oxidation to tetraalkylthiuram disulphides. The metal salts were found to exert no influence on the decomposition of dithiocarbamates in the presence of oxygen. However, the dithiocarbamates decomposed heavily in the presence of carbon dioxide into the secondary amine, carbon disulphide and alkali. A new addition compound, tetraisobutyldithiocarbamate, was isolated for the first time and characterized. The acid decomposition has been found to follow a first order rate equation.

The contact angle is a measure of the degree of hydrophobicity attained by a mineral surface consequent on collector adsorption. Since hydrophobic surface is a necessary prerequisite for flotation, the extent of hydrophobicity attained by various sulphide mineral surfaces like sphalerite, galena, iron pyrite, chalcopyrite and marmatite as a result of the adsorption of dithiocarbamates was studied as a function of *p*H employing the captive bubble method of measuring contact angles. It was found that in general the adsorption of dithiocarbamates depends on the type of the mineral, the nature of the exposed mineral plane, the hydrogen ion concentration and the nature of the hydrocarbon chain of the dithiocarbamate. The adsorption studies also revealed that on sulphide minerals possessing sodium chloride type cubic lattice, viz. galena and iron pyrite, adsorption of dithiocarbamates is uniform as revealed by characteristic contact angles, while on sphalerite and marmatite, which possess diamond type cubic lattice, and on chalcopyrite, which has a tetragonal superstructure of sphalerite, the contact angles are invariably low. The observation is explained on the basis of differences in exposed planes of the minerals available for adsorption.

Dialkyldithiocarbamates are not oxidized at the surfaces of sulphide minerals and are efficiently adsorbed even from thoroughly deoxygenated aqueous solutions. Consequently, it is concluded that oxidation of a dithiocarbamate is not a prerequisite for its adsorption on a sulphide mineral as was found in the case of alkylxanthate collectors. The results also showed that: (i) it is possible to selectively float chalcopyrite from iron pyrite in an alkaline medium ($p\text{H} > 9{\cdot}0$) using dialkyldithiocarbamates as collectors; and (ii) galena (PbS) can be selectively floated at and above *p*H 7 with these collectors from sphalerite (ZnS) in the absence of any depressants for the latter (the conventional collectors can separate galena from sphalerite only if the latter is depressed first with zinc sulphate/cyanide). Sphalerite can be recovered by flotation subsequently after reactivation with cupric sulphate. Accordingly, flotation experiments were carried out with a chalcopyrite-iron pyrite ore (Chitradurg, Mysore) and lead-zinc ore (Dariba, Udaipur). In order to arrive at optimum conditions for an efficient separation, the effect of (1) particle size of the ores, (2) *p*H of flotation pulps, (3) nature of the hydrocarbon chain of the collectors, and (4) amounts of the activator and collectors on the recoveries and grades of the mineral concentrates has been investigated. The best results are obtained by employing the following conditions.

Selective flotation of chalcopyrite

(1) The particle size of the ore should be $-200+270$ (Tyler standard) at which chalcopyrite is liberated from iron pyrite and gangue minerals; (2) the flotation pulp containing 15% solids should have a *p*H of 10; and (3) the amounts of the activator (cupric sulphate) and collector should be 0·75 lb and 0·01 lb per ton of the ore respectively.

The amount of dithiocarbamate employed is one-fourth that of ethyl xanthate employed in industry.

Selective flotation of galena and sphalerite

(1) The particle size of the ore should be $-200+250$ (Tyler standard) at which both galena and sphalerite are completely liberated from each other and from gangue minerals; (2) the flotation pulp containing 15% solids should have a *p*H of 8 for selectively floating both galena and sphalerite; (3) the amount of the collector should be 0·05 lb per ton of the ore for both galena and sphalerite; and (4) the amount of the activator required for the selective flotation of sphalerite is 2·0 lb of cupric sulphate per ton of the ore.

The quantity of dithiocarbamate collector required is one-fourth to one-half the amount of ethyl xanthate employed in industry.

Diisobutyldithiocarbamate in particular and diethyl, di-n-butyl and diisopropyldithiocarbamates in general, are shown to be superior collectors in the flotation of sulphide minerals as they give better grades and recoveries.

Shri Ravindranath (presently at the Publications & Information Directorate, New Delhi) was awarded the Ph.D. degree (1970) of the Indian Institute of Science, Bangalore for his thesis entitled 'Studies on dialkyldithiocarbamate collectors with reference to sulphide minerals'.

Studies in Proximity Spaces

Studies made under a CSIR research scheme entitled 'Proximities and extensions of continuous functions' at the Department of Mathematics, Indian Institute of Technology, Kanpur have led to a unified approach based on the concept of proximities defined on sets for tackling the two major problems of general topology, viz. the compactification problem and the problem of continuous extensions of functions from dense subspaces.

Starting from basic definitions and fundamental theorems on extensions of functions, a satisfactory generalization of the well-known Smirnov compactification theorem for EF-spaces has been derived for LO-spaces. From an analysis of the conditions regarding extensions of continuous functions it has been shown that the extension results of Taimanov, McDowell, Blefko and Engelking are easy consequences of a single theorem and that new extension theorems could be found which extend Taimanov's result to cases when the range space of the continuous map is some generalization of compact spaces.

Making use of deductions obtained from the various compactifications of topological spaces, a necessary and sufficient condition for a Hausdorff compactification to become a Wallman compactification has been derived and this leads to the well-known theorem of Ponomarev.

From a comparative study of the characteristics of S-, EF- and LO-spaces, it is proved that every S-space has a compatible T_1-topology and that it also has a compatible generalized uniform structure.

The study of the problem of proximal embedding of S-spaces has shown that every abstract S-proximity is a subspace S-proximity of δ_0' under certain conditions. The generalization of Smirnov theorem for S-spaces has also been deduced, and by extending the results obtained on LO-spaces to the S-spaces, further variations of Taimanov's results have been obtained.

The studies were made by Miss Mani Gagrat, a CSIR research fellow, under the direction of Prof. R. S. L. Srivastava, Head of the Department of Mathematics, IIT, Kanpur. Miss Gagrat was awarded the Ph.D. degree (1970) of the Institute for her dissertation relating to the work.

Spectroscopic and Optical Studies of Crystals

The triggering mechanism in ferroelectric crystals is of technological importance. The reorientation of the complex ions and/or of the hydrogen bonds plays an important role in the ferroelectric mechanism. These changes manifest themselves in the vibration spectrum. Studies on the infrared and Raman spectra of hydrogen bonded, ferroelectric and related crystals were undertaken to obtain information on the effect of crystalline field on the vibrations of complex ions and the effect of H-bonding on the vibration spectra with the object of deducing a mechanism of phase transition in 'soft' ferroelectrics.

The Raman spectra at different temperatures were obtained with Hilger medium and giant quartz spectrographs, and the infrared spectra were recorded using Perkin-Elmer model 112 single beam infrared spectrometer and a Carl Zeiss UR-10 double beam spectrometer. Polarized Raman and infrared spectra were obtained in some cases.

From the Raman and infrared studies of $BaCl_2.2H_2O$ and $SrCl_2.2H_2O$, it is shown that the water molecules in $SrCl_2.2H_2O$ form stronger H-bonds than in $BaCl_2.2H_2O$. The vibrational frequencies due to the two families of water molecules have been obtained by an analysis of the spectra.

The Raman and infrared studies on the addition compounds of glycine with Ba, Sr and Ca chlorides show that the H-bond strength and the different frequencies decrease in the sequence Ca>Sr>Ba. These studies also show that one of the carboxyl oxygens is weakly coordinated to the metal ion and that the covalent character of the metal-oxygen bond decreases in the sequence Ca>Sr>Ba. The infrared studies on the equilibrium mixtures of $DGBaCl_2.H_2O$ show a strong coupling among different vibrations.

The α, β and γ alums differ in the internal arrangement of ions. From the Raman and infrared studies on methylammonium alums at different temperatures, the changes in the structure during the ferroelectric transition have been discussed. The characteristic differences in the Raman spectra of the α, β and γ alums were correlated with the structural differences in these alums.

A comparison of the infrared spectra of the aluminium, chromium and ferric alums shows no systematic variation of the frequencies of the sulphate group vibrations with the radius of the trivalent or the monovalent cation. The frequencies of the internal vibrations of the complex ion, $M^{3+}(H_2O)_6$ were evaluated by Wilson's FG-matrix method. A comparison of the infrared spectra

of the anhydrous alums suggests that the sulphate group forms a unidentate complex with the trivalent cation in the anhydrous aluminium and ferric alums and a bidentate complex in the anhydrous chromium alums.

Shri G. M. Venkatesh, who carried out these studies under the guidance of Prof. P. S. Narayanan at the Department of Physics, Indian Institute of Science, Bangalore, and who is presently at the Ahmedabad Textile Industry's Research Association, Ahmedabad, was awarded the Ph.D. degree of the Indian Institute of Science (1970) for his thesis entitled 'Spectroscopic and optical studies of crystals'.

PATENTS ACCEPTED

Indian Pat. 121776 & 121777

Unevenness indicator for indicating pavement irregularities and marking or/and indicating device suitable for attachment to an unevenness measuring machine

M. P. Dhir, A. K. Bhat, S. S. Rup, B. D. Ved & J. Mitter
CRRI, New Delhi

The two patents are in respect of the unevenness indicator, a quality control tool for the surface evenness of highway and air-field pavements.

The indicator (*CSIR News*, Vol. 20, *p.* 130) consists of a tubular frame with handles and datum wheels on both ends and a probing wheel in the middle. The upward and downward movement of the probing wheel in relation to the datum of the end wheels is carried for indication on a dial with a pointer to an enlarged scale. The relative movement of datum wheel is also arranged to operate a colour spray valve and a buzzer circuit. The device indicates not only the magnitude of surface irregularities but also the locations with excessive irregularities by throwing colour on the surface as well as through buzzer sound.

Indian Pat. 116538

Improvements in or relating to the preparation of lead sulphide photoconductive cells for infrared detection

C. V. Suryanarayana, H. N. V. Rao, K. K. J. Pillai, V. Subramanian, K. Ramakrishnan & Y. V. P. R. Row
CECRI, Karaikudi

Thin layers of lead sulphide are responsive in the infrared region (1-3.5 μ) with a maximum sensitivity at 2.1 μ and are best suited for use at normal temperature. At present the most widely used method for preparing photosensitive layers of lead sulphide is the chemical deposition based on the reaction between lead acetate and thiourea in an alkaline medium. The chemical method of deposition reported in literature is rather critical in the sense that the cells prepared in accordance with the procedure given do not exhibit photosensitivity claimed by the workers.

The patent under reference relates to the modification of the process for getting reliable deposits. One of the modifications is the addition of lead monoxide (1-2 g) and alkali halides like bromides and iodides to the depositing bath, as a result of which the sensitivity of the cells is enhanced. An important step newly introduced in the modified process is the subsequent heat-treatment of the chemically deposited layers in an atmosphere of oxygen (pressure, 1 atm) at 500°-600°C for 5-15 min. For protecting the sensitive layers against deleterious moisture in the atmosphere, an indigenously available plastic material has been found useful.

The lead sulphide infrared detectors prepared with these modifications compare favourably with most of the imported brands of cells, such as Infratron of USA and Mullard make of UK.

Indian Pat. 18517

Insecticidal vaporant for household and industrial pest control

S. M. Ahmed & S. K. Majumder
CFTRI, Mysore

In contrast to the existing laborious methods for household and industrial pest control by dusting, spraying, fogging and aerosols, a new product, which is simple and effortless in application, has been developed. The insecticidal vaporant releases vapour in the enclosed space at optimum rate for controlling the pests within the safe concentration for higher animals in contrast to the products available for the purposes.

The present invention relates to the development of the formulation and application technique based on DDVP (O,O-dimethyl-2,2-dichlorovinyl phosphate). A process has been developed for making an insecticidal evaporant particularly suited for dispensing in the form of strip or slab for household and industrial pest control. The carrier consists of strip, slab or grains made from cellulosic residues impregnated with mixtures of DDVP, solvent and oil based stabilizers. A protective film has been provided to prevent its hydrolysis and at the same time to permeate DDVP preferentially. Long storage of the vaporant strips has been achieved by providing a removable envelope of polycel. The formulation contains the smallest quantity of active ingredient in the strip and stabilized for long periods (2-3 months) at high temperatures 23°-45°C and 60-98% R.H. A strip of 100-110 g is sufficient for 1000 ft^3 space for use in residential establishments, restaurants, dairies, cattle sheds, refrigerators, wardrobes and food processing plants for effective control of house-flies, mosquitoes, cockroaches, eye gnats, cloth moth, silver fish and other flying insects.

Symposium on Pumps, Compressors, Blowers and Fans

A symposium on 'Pumps, compressors, blowers and fans' will be held at the Central Mechanical Engineering Research Institute, Durgapur on 5 and 6 March 1971. The object of the symposium is to highlight the various aspects of fluid machinery such as pumps, compressors, blowers and fans and identify the areas of research and development work of immediate interest to industry. There will be four scientific sessions, one each on pumps; compressors; and blowers and fans; and the fourth session will be devoted exclusively for the delegates from industries to discuss and formulate research programmes in these three fields.

Scientists desirous of participating in the symposium may send the complete manuscript of their papers to the convener of the symposium by 31 January 1971.

All communications regarding the symposium are to be addressed to the convener, Shri P. R. Sadasiva, Central Mechanical Engineering Research Institute, Durgapur 9.

Printed & published by A. Krishnamurthi, Chief Editor, Publications & Information Directorate, New Delhi, at Delhi Printers, Delhi
RN4212/5